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Ultra-Rapid Nickel-Cadmium Battery Charger

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There are many applications where nickel cadmium batteries are used in portable equipment and charging them can be a problem when the voltage exceeds the available charging source voltage. For instance, electric flight hobbyists are well aware of the problems that occur when charging over eight nickel-cadmium batteries while in the field. The problem occurs when the voltage of the batteries to be charged exceeds that of the charging source, which would typically be a 12 volt automotive battery. We are going to present an ultra-fast nickel-cadmium battery charger capable of completely charging 8 to 12 batteries at 1.2 to 1.8 Ah in 30 to 45 minutes. This is currently possible due to new sintered electrode technology used by battery manufacturers which provide rapid charging plots.

SPECIFICATIONS AND FEATURES

The following are the technical specification and features of the battery charger:

- 10 to 14 volt input voltage
- 1 to 3.5 A constant output current
- Twenty volt maximum output voltage
- Automatic shut-off
- Protection against polarity inversion
- Short-circuit protection
- Open-circuit protection

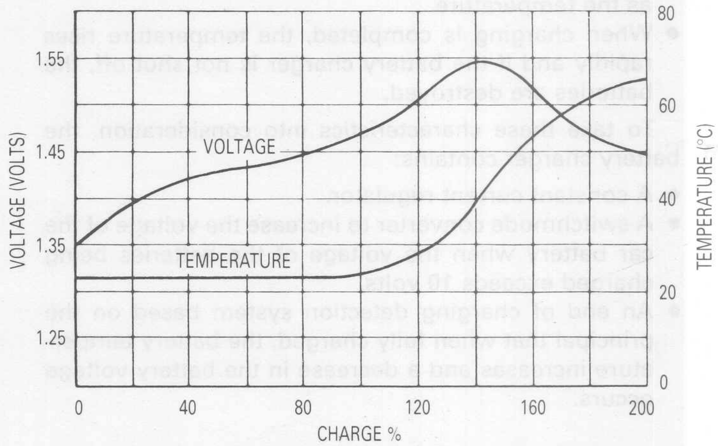

Figure 1. Battery Charging Characteristics

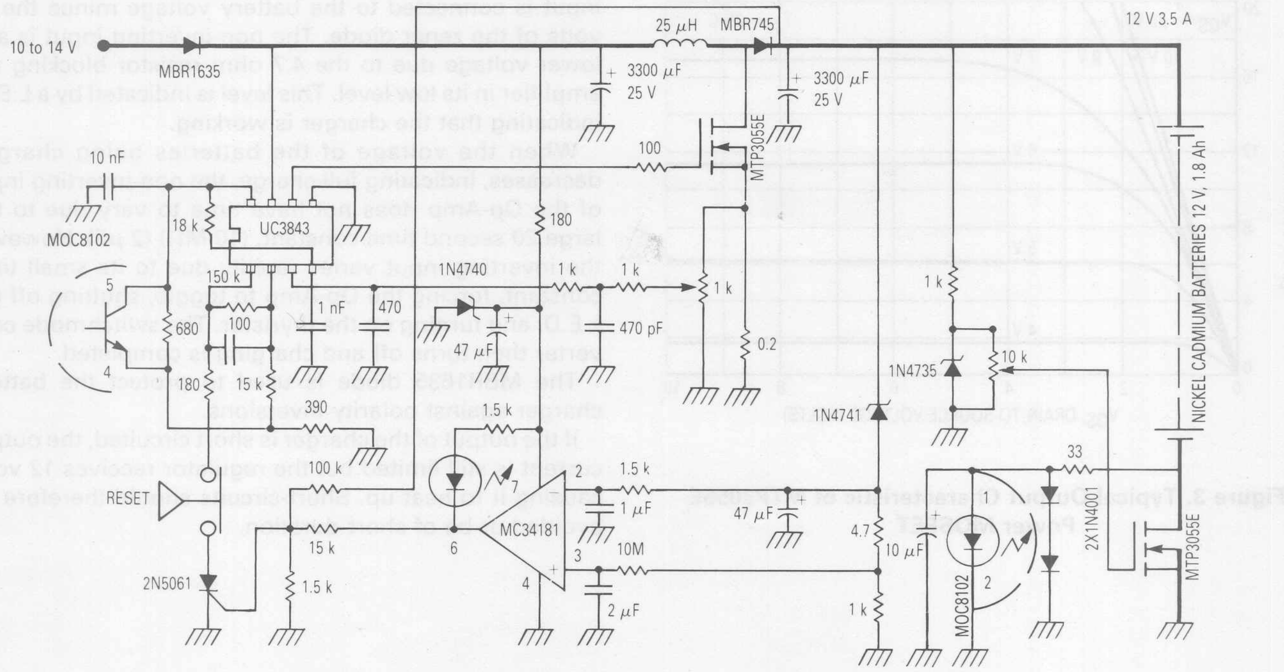

Figure 2. Self Contained Ultra-Rapid Nickel Cadmium Battery Charger

OPERATIONAL DESCRIPTION

The design of the battery charger depends upon the following battery characteristics:

- A nickel-cadmium battery must be charged with a constant current.
- A battery is completely charged when it reaches 140% of its maximum charge (it takes 45 minutes to charge a 1.8 Ah battery at 3.5 A).
- The variation of the battery voltage as a function of the charge depends upon the state of the charge as well as the temperature.
- When charging is completed, the temperature rises rapidly and if the battery charger is not shut off, the batteries are destroyed.

To take these characteristics into consideration, the battery charger contains:

- A constant current regulator.
- A switchmode converter to increase the voltage of the car battery when the voltage of the batteries being charged exceeds 10 volts.
- An end of charging detection system based on the principal that when fully charged, the battery temperature increases and a decrease in the battery voltage occurs.

THE CONSTANT CURRENT REGULATOR

This regulator uses a Motorola MTP3055E TMOS Power MOSFET which has a variable operating point allowing adjustment of the charging current. This charging current is relatively independent of the Drain-Source voltage (V_{DS}) when V_{DS} exceeds 2 volts as shown in Figure 3.

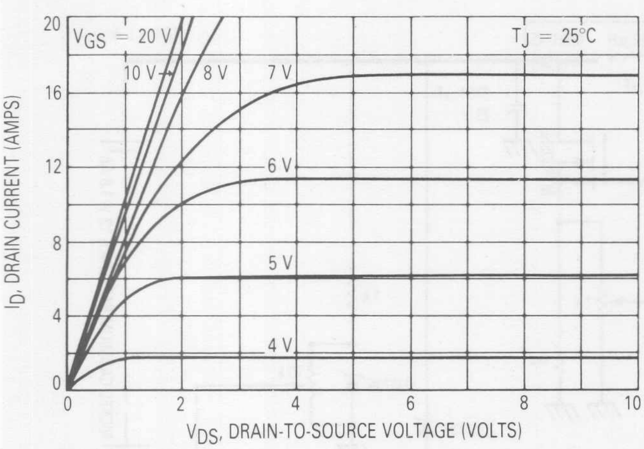

Figure 3. Typical Output Characteristic of MTP3055E Power MOSFET

The charging current will therefore remain constant for large variations of the car and nickel-cadmium battery voltages.

THE SWITCHMODE CONVERTER

The converter is used to increase the charging voltage so that the current regulator always has an input of at least 2 volts. It uses the Motorola UC3843 I/C produced specifically for automotive applications. This I/C used in conjunction with a TMOS MTP3055E, a MBR745 Schottky diode and a 25 μH inductance make up the voltage converter. The operating frequency of 100 kHz allows the use of the small inductance. A MOC8102 optocoupler monitors the voltage applied to the current regulator and brings this information to the error amplifier of the UC3843. When a decrease in voltage is sensed, the UC3843 reacts to maintain a voltage, V_{DS}, of around 2 volts at the input of the current regulator. This maintains an approximate maximum power dissipation in the regulator of (2 V) (3.5 A) = 7 W.

The output voltage of the switchmode converter is therefore floating and stays at 2 volts above the voltage of the batteries to be charged.

If at some instant the batteries to be charged are not connected, the output voltage can exceed 40 volts. Should this happen, a 2N5061 thyristor which is sensitive to this overvoltage immediately turns off the converter.

THE DETECTION SYSTEM

The control of the output voltage and the automatic shut off at full charge are assured by the combination of the MC34181 operational amplifier and the 2N5061 thyristor. The Motorola MC34181 Op-Amp uses JFET's with very high input impedance and low offset voltage. It is used as a comparator in the battery charger. The inverting input is connected to the battery voltage minus the 11 volts of the zener diode. The non-inverting input is at a lower voltage due to the 4.7 ohm resistor blocking the amplifier in its low level. This level is indicated by a L.E.D. indicating that the charger is working.

When the voltage of the batteries being charged decreases, indicating full charge, the non-inverting input of the Op-Amp does not have time to vary due to the large 20 second time constant, (10 MΩ) (2 μF). However, the inverting input varies rapidly due to its small time constant, forcing the Op-Amp to toggle, shutting off the L.E.D. and turning on the thyristor. The switchmode converter then turns off and charging is completed.

The MBR1635 diode is used to protect the battery charger against polarity inversions.

If the output of the charger is short circuited, the output current is still limited but the regulator receives 12 volts causing it to heat up. Short-circuits should therefore be avoided or be of short duration.

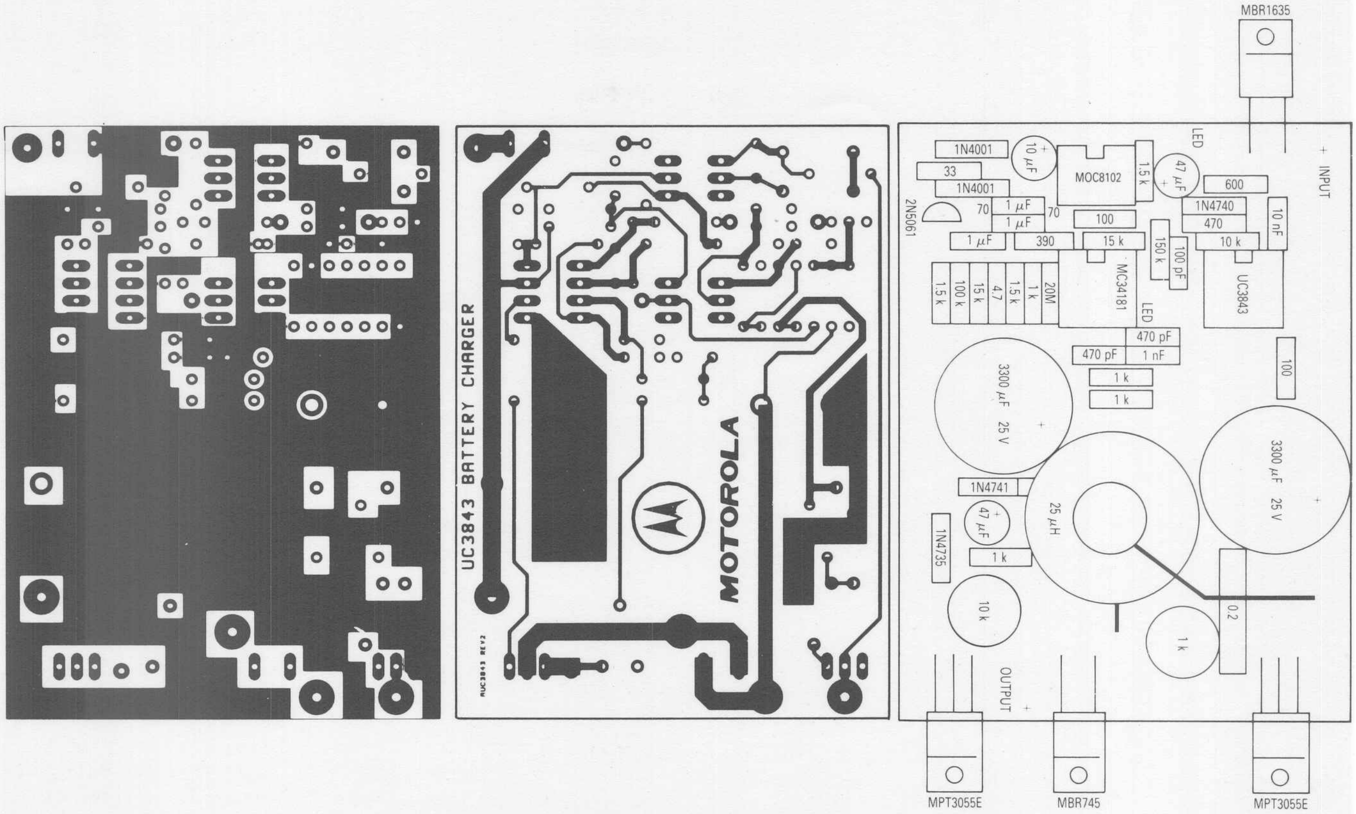

Figure 4. Printed Circuit Board and Circuit Layout

COMPONENTS

I/Cs
1 MC34181
1 UC3843
1 MOC8102

Diodes
2 1N4001
1 MBR745
1 MBR1635
1 LED
1 1N4735
1 1N4740
1 1N4741

Transistors
2 MTP3055E
1 2N5061

Capacitors
2 3300 μF 25 V
2 47 μF 6 V
1 10 μF 6 V
3 1 μF 50 V (ceramic)
1 10 nF ceramic
2 470 pF ceramic
1 1 nF ceramic
1 100 pF ceramic

Resistors
1 0.2 ohm
1 4.7 ohm
1 33 ohm
1 100 ohm
1 180 ohm
1 390 ohm
1 680 ohm
4 1 Kohm
3 1.5 Kohm
2 15 Kohm
1 18 Kohm
1 100 Kohm
1 150 Kohm
2 10 Mohm

Miscellaneous
1 1K (adjustable)
1 10K (adjustable)
1 Push Button
1 Box
1 6 A Ampmeter
1 Core: Magnetics 58930A2
12 Turns of 15/10 Enameled Wire

PERFORMANCE

After having charged ten nickel-cadmium batteries to 15 volts at 3.5 A, the current of the 12 volt car battery will equal 5.5 A. The power of the nickel-cadmium batteries is therefore equal to (15 V) (3.5 A) = 52.5 W and the input power is (12 V) (5.5 A) = 66 W. This gives an efficiency of 52.5/66 = 79.5%.

CONCLUSION

For approximately $50 this dependable and efficient nickel-cadmium battery charger can be built and used to charge batteries for various applications.

COMMENTS

For additional protection, a timer can be added to the charger to limit the duration of the charging.

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